2012

Agricultural Productivity in China: National and Regional Growth Patterns, 1993-2005

Hazhi Tong

Lilyan E. Fulginiti
University of Nebraska-Lincoln, lfulginiti1@unl.edu

Juan Sesmero
Purdue University

Chapter 9

Agricultural Productivity in China: National and Regional Growth Patterns, 1993-2005

Haizhi Tong
Lilyan E. Fulginiti[1]
Juan P. Sesmero[2]

Abstract. Agricultural productivity growth in Chinese provinces is examined for the 1994-2005 period. It is studied using a data set seldom used and with two alternative approaches. Results show that productivity growth rates have been high, about 4 percent, on average, during the period. The East outperformed the Central region, which in turn outperformed the West. Growth rates show a slight slowdown during the 1990s, an increase in the early 2000's, and a slowdown in 2004 and 2005. While the Malmquist estimates show convergence between the East and the West, the stochastic frontier estimates do not show the same pattern.

Keywords: Provincial TFP growth, stochastic production frontier, Malmquist index.

JEL Classification: O4, O5, Q1

[1] Department of Agricultural Economics. University of Nebraksa, Lincoln, NE 68583-0922. Contact author: lfulginiti@unl.edu
[2] Department of Agricultural Economics. Purdue University, West Lafayette, IN, 47907.

Agricultural Productivity in China: National and Regional Growth Patterns, 1993-2005

Introduction

Since the economic reforms of 1978, China's agricultural sector has had an impressive performance. According to China's statistical yearbook, by 2005 output from farming, forestry, animal industry and fishery had increased by more than four times since the reforms were initiated. China has nine percent of the world's total arable land, twenty percent of the world's population with seventy percent living in rural areas.

Many studies have examined Chinese agricultural growth. These studies point towards rapid expansion of agricultural output and productivity during the 1980's and a slow down during the 1990's raising questions about the sustainability of these growth rates. Few of these studies cover the 2000's and most estimate productivity at the national level rather than the provincial level.

In this study our objective is to examine *regional* agricultural productivity growth in China twenty years after the introduction of reforms in the sector. China is a country with diverse ecosystems and it is relevant to identify how productivity growth patterns differ across regions. We focus on the 1993-2005 period, which includes 1998 the year in which some of the reforms of the 1970's were due to expire, in particular the 20-year leases on land. Most commonly one would develop a Fisher or Tornquist productivity index from observed price and quantity data as it is done by USDA for U.S. states but prices and input shares are not available. Even if they were, these prices would not represent opportunity costs given the high degree of interventions in the economy, including the strong restrictions on input mobility. With only quantities used and produced available from China's Statistical Yearbook (CSY) we estimate multifactor productivity growth (TFP) with a nonparametric Malmquist index and alternatively with a stochastic and parametric production frontier. The period of analysis is critical as during these years some of the policies and contracts implemented by the Household Responsibility System of the 1970's were due to expire. This may have increased uncertainty considerably, possibly having a stifling effect on productivity growth.

Several issues motivate the present study. First, most studies on Chinese agricultural productivity are done at the national level using FAO data. Some have focused on specific agricultural commodities. For this analysis we use provincial data from an alternative source, China's Statistical Yearbook. Second, the period of analysis in this study corresponds to the twentieth anniversary of the reforms implemented in the 1970's. A slight slowdown in output growth was observed during the late 1990's raising concerns that the rapid growth of the previous twenty years was fueled by increases in inputs rather than by innovations. By 2003 though the rate of output growth picked up, returning to pre-1996 levels. Third, we use two very different approaches to the measurement of productivity growth, one stochastic and parametric, the other non-parametric and non- stochastic with the objective of identifying sensitivity to choice of technique.

We find that productivity growth in Chinese agriculture has been higher in the mid 1990's than in the late 1990's, consistent with a slowdown mentioned by others. But we also find indication of a trend reversal around 1998 with productivity picking up pace again in the 2000's.

China's Agricultural Policies

Before 1978, agriculture in China was under a collective system. The first step in China's agricultural reform was the introduction of the "household production responsibility system" (HRS) in 1978. Under the HRS system, farmland is not privately owned but farmers have long term user rights. They are also free to allocate resources as they see fit but were required to deliver a quota to the government at procurement prices. The leftover output could be traded freely in the market. The objective was to align market signals to farmer's incentives to encourage them to raise output, reduce costs and adopt new technologies. Under this system, the fruits, vegetables and livestock markets have been less controlled than the grain markets. While farmers pay taxes and local fees, the local government is responsible for extension services and for the introduction of new technologies and seed varieties.

A second step in the reform process occurred at the beginning of the 1990's, when China abandoned its food rationing system. Under the grain-rationing system, urban consumers used coupons to buy a fixed amount of grain at a low price, with more available at market prices. Due to budget pressures in 1991-1992, the government reduced the gap between controlled and market prices finally eliminating it in 1994 as no resistance from urban consumers materialized.

An important reform was introduced in 1995, the Grain-Bag responsibility system, requiring leaders in each province to maintain overall balance of grain supply and demand within each province and to regulate local markets. This policy advocates self-sufficiency in grain production and resulted in potentially inefficient reallocation of resources towards grain production.

More recently, the following important reforms were introduced. In 1998 a second HRS wave replaced the one introduced in 1978 as land leases expired and were replaced by new ones. Starting in 2000, taxes to the farming sector were gradually eliminated. In 2001, China became a member of the WTO.

Other Studies

We find numerous studies of agricultural productivity growth in China. They covered different periods, different aggregation levels, used different data sets and different methodologies. We discuss here these studies and their findings. We focus our attention, however, in those studies that report yearly estimates of total factor productivity growth in Chinese agriculture overlapping with the years covered by this study. Summary of these studies is given in Table 1.

McMillan, Whalley and Zhu (1989) examined agricultural performance in 1978-1984 and the effects of price increases and of the institutional reform introduced by the household responsibility system (HRS). Fan (1991) used a frontier production function to separate agricultural growth into input growth, technical change, institutional reform, and efficiency change. Lin (1992) employed a fixed effects model on provincial data to evaluate the effects of decollectivization (HRS), price adjustments and other factors on productivity growth. In a follow up paper, Lin (1993), studied the issue of efficiency of different systems and showed that household farms outperformed cooperative farms, which gave support for institutional reform in China. In yet another study, Lin (1995) examined rice production and tested the induced institutional innovation theory. A study by Huang and Rozelle (1995) used data from 1952 to 1990 and found that environmental stress was an important factor in reducing TFP growth after the mid 1980's. Spitzer (1997) applied a nonparametric index number approach to decompose total factor productivity in China's agriculture. He found that technical change was positive and efficiency change negative during the period from 1985 to 1994. Zhang and Carter (1997) constructed a Cobb-Douglas production function to separate the contribution of inputs, weather and efficiency to growth of grain production from 1980 to 1990.

Zhang and Fan (2001) used a generalized maximum entropy approach to estimate a multi output production technology for twenty-five provinces during the period of 1979-1996. They did not, however, calculate and decompose total factor productivity growth. Jin et al. (2010) use a stochastic production frontier function approach to estimate the rate of change in TFP for 23 of China's main farm commodities. To do so they rely on the National Cost of Production Data Set. They find negative rates of efficiency change outweighed by positive rates of technical change. They do not, however, report yearly productivity growth at an aggregate level.

Regarding the role of market institutions and transaction costs on productivity, Rozelle et al (1997) examined market integration after the implementation of liberalized economic policies in food markets. Rozelle, Taylor and DeBrauw (1999) used a labor migration framework to model the effect of migration and remittances on agricultural productivity growth in China. DeBrauw, Huang and Rozelle (2000) examined how market liberalization influenced the behavior of producers.

Many authors have estimated agricultural productivity growth based on data from FAO in a multi-country context, including China. Coelli and Rao (2005) used a DEA approach to Malmquist indices of TFP growth for many countries based on data from FAO for the period 1980-2000. They found that agricultural TFP in China grew at an average yearly rate of 1.06% during this period. Bravo-Ortega and Lederman (2004) also use FAO data to calculate agricultural TFP growth for China (among other countries) during the 1961- 2000 period. They estimate a translog production function and calculate TFP as a residual. While they found that the Chinese agricultural TFP grew 1.67%/year in this period, they do not report annual figures of TFP growth after 1994. Ludena et al. (2007) constructed TFP indices for Chinese agriculture based on a DEA directional distance function. Using data from FAO, they calculated an average agricultural TFP growth of 3.05%/year for the period 1990-2000, consistent with Bravo-Ortega and Lederman (2004). These studies did not report yearly TFP growth estimates and, hence, are not directly comparable to our analysis.

A number of studies have calculated and decomposed agricultural total factor productivity growth in China within a time frame overlapping (at least partially) with that considered in this analysis (see Table 1). Using provincial data, Lambert and Parker (1998) constructs a Divisia index for the period 1979-1995. They found an increase in total factor productivity of 5.8% per year in the period 1993-1995. Jin et al. (2002) also used an accounting approach and constructed a Tornqvist index. They concluded that new technologies were the main driver of agricultural productivity growth during the period 1980-1995. However, in contrast with Lambert and Parker (1998), they found that total factor productivity declined by3.2% per year in the period 1994-1995. Mead (2003) reexamines data on Chinese agricultural productivity growth using an alternative calculation of China's labor force. This estimate is employed in a TFP calculation based on a constant-returns-to-scale Cobb Douglas production function. He finds a strong correlation between policies and productivity growth and 1984-1999. In contrast, Dekle and Vandenbroucke (2006) calculating productivity growth in China as a residual based on a constant-returns-to-scale Cobb Douglas approximation to the technology, found a strong TFP growth in the period 1994-2003 (6.6% per year).

Using national data, Wu et al. (2001) constructed Malmquist indices for the period 1980-1995. They found that TFP grew at an annual rate of 2.3% in the 1994-1995 period. This is in line with Wu et al. (2001), Colby, Diao and Somwaru. (2000), Fan and Zhang (2002), Hsu, Yu and Chang (2003), Lezin and Wei. (2005), and Bosworth and Collins. (2008) who found a rather strong growth in agricultural TFP during different parts of the 1994-2005 period.

Colby Diao and Somwaru (2000) used a Tornqvist index to analyze the sources of output growth in grains and in four major crops in China (rice, wheat, corn and soybean). They found that agricultural TFP grew, on average, at an annual rate of 0.8%. Fan and Zhang (2002) adjusted previous measures of growth in outputs and inputs and calculated a Tornquist-Theil index of TFP at the national and provincial levels for the period 1952-1997. In particular, they found an increase in TFP during the period 1978-1997. Lezin and Wei. (2005) also estimated a Cobb Douglas production function for the province of Zhejiang and found a positive TFP growth in the period 1994-1997. Hsu Yu and Chang (2003) calculated output-orientated Malmquist productivity indexes using a non-parametric DEA (Data Envelopment Analysis) approach covering the period 1984-1999. They estimated that TFP growth was, on average, 1% per year. Bosworth and Collins (2008) calculate productivity growth in China as a residual based on a constant returns to scale Cobb Douglas approximation to the technology. They calculate average national productivity of China and India and compare their performance in the period 1978-2004. They estimate China's agricultural TFP growth at 1.7% per year in the 1993-2004 period.

In a cross-country study, Fuglie (2008) estimated an annual rate of TFP growth in Chinese agriculture of approximately 3.5% from 1990 to 2006. Nin Pratt, Yu and Fan (2009) also using in a multi-country study context, and with FAO data calculate both a Tornquist-Theil index and a Malmquist index of TFP growth for China. They found increases in Chinese agricultural productivity in the post-reform period up until 2003 (growth averaged 5% per year when calculated with a Malmquist index and 3% with a Tornqvist-Teil index). They also found that both efficiency and technical change were important drivers of productivity growth and that returns to agricultural R&D had been high.

Based on the above studies, we learn that:

1) Studies have used data from the Chinese Statistical Yearbook, and from FAO. In general, studies that use FAO data show higher TFP growth rates for 1970-2000.
2) Methodologies used include econometric estimation of production functions, some of them stochastic frontiers, growth accounting TFP indices, and data envelopment analysis (DEA).
3) Studies cover different periods that extend from the time when policy reforms were introduced up until the early 2000's.

Estimates indicate that agricultural productivity growth in China was higher immediately after the introduction of the Household Responsibility System (from 1978 to mid 80's) making institutional reform the main contributor to TFP growth in that period. However, there is evidence that TFP growth slowed down after that period and towards the end of 1990's which was speculated to be due to exhaustion of the institutional effect, the introduction of the procurement price system, environmental stress, or lack of agriculture investments and innovations that hindered further gain in productivity growth.

Regional Productivity Growth

Productivity refers to output per unit of input and can be measured using different approaches. We care about productivity growth because it indicates an increase in output in perpetuity. The most direct way to measure productivity is by constructing indexes of outputs and inputs with costs and revenue shares as weights. Given the difficulty in obtaining these shares, two alternative methods are used in this paper: a nonstochastic, Malmquist index and a stochastic production frontier. Both methods allow for estimation of the rate of productivity growth when no reliable information on prices is available. We refer to this rate as the total factor productivity (TFP) growth rate.

Data

Data used are from China Statistical Yearbook (CSY) for thirty "provinces" during 1993-2005. Some of these provinces are municipalities like Beijing, Shanghai, and Tianjin. Sichuan includes Chongqing, considered since 1997 a provincial-level municipality. Others are not provinces but autonomous regions like Inner Mongolia, Tibet, Xinjiang, Ningxia, and Guanxi. Hainan is an island province. We use agricultural output (gross output value for the agriculture sector, including farming, forestry, animal industry and fishery) in constant 1993 Yuans and the corresponding quantity indexes converted using 1993 as the base year. We obtain the 1993 data from 1994 China Statistical Yearbook (page 330, Agriculture, table 11-4 Gross Output Value and Indices of Farming, Forestry, Animal Husbandry and Fishery), the 1994 data from the same table but in the1995 China Statistical Yearbook. The data from 1995-2005 can be found on–line.

. The following inputs used in the analysis are also obtained from corresponding tables in the Agriculture chapter of the China Statistical Yearbook. They are: total sown areas, agricultural machinery, labor, and fertilizer. Fertilizer includes nitrogen, phosphate, potash and compound fertilizer. Table 2 summarizes the data at the national level. (data by province is available from the authors).

The Malmquist Index

The Malmquist index used in this study is the version specified by Färe, Grosskopf and Lovell. (1994). Productivity change is decomposed into efficiency change (first term) and technical change (second term)

$$M_0(x_{t+1}, y_{t+1}, x_t, y_t) = \frac{D_o^{t+1}(x_{t+1}, y_{t+1})}{D_0^t(x_{t,} y_t)} \left[\frac{D_o^t(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_{t+1,} y_{t+1})} * \frac{D_o^t(x_t, y_t)}{D_0^{t+1}(x_{t,} y_t)}\right]^{1/2} \qquad (1)$$

where D_o is the output distance function, x and y are input and output vectors, and t indicates the time period. Data Envelopment Analysis (DEA), a programming approach, is used to calculated D_o as follows (Coelli 2008):

$$[D^t{}_o(x_{t,}y_t)]^{-1} = \max_{\phi,\lambda,} \phi,$$

$$\text{st.} \quad -\phi y_{it} + Y_t\lambda \geq 0, \qquad (2)$$

$$x_{it} - X_t\lambda \geq 0,$$

$$\lambda \geq 0$$

where X and Y are the *(K*N)* input and the *(M*N)* output matrices respectively. λ is a *N*1* vector of constants, or intensity variables. Here $1 =< \varnothing < \infty$ and $(\varnothing - 1)$ is the proportional increase in outputs achieved by the *i-th* region while maintaining input quantities constant. This approach constructs the production surface as an envelope of the observations each period, defined by those representing best performance.

Technical efficiency change, also known as the ‘catching up’ component of the index, indicates whether a particular region is moving closer or further away from the frontier. Technical change, or the innovations component of the index, refers to a shift of the best practice frontier. Indexes smaller than one represent deteriorations. The Malmquist index is calculated with information from two consecutive data periods and it is very sensitive to extremes but it is free of specification error. We use Coelli’s DEAP programming code to compute the Malmquist index and its components.

Table 3 reports the national average rate of productivity growth derived using the Malmquist method and breaks this down into technical change and efficiency change components. China experienced high rates of productivity growth in 1994 and 1995 followed by a decrease from 1996 to 1998, and a reversal of this trend after 1999 with annual productivity growth rates between 4% and 2% between 2000 and 2005. On average, total factor productivity growth in Chinese agriculture during 1993-2005 was a robust 3.97% annually, compared to 1.73% productivity growth in U.S. agriculture during the same period.

Table 4 reports average productivity rates of growth for each province and region, also using the Malmquist method.[3] Most provinces experienced positive TFP growth, mainly as a result of technical change resulting from the adoption of new innovations. Jiangsu, Fuijan, and Liaoning were the best performers with average annual TFP growth rates of 6% to7%. The rural areas around Beijing and Shanghai were also strong performers, probably due to a shift in output toward higher-valued vegetable and fruit production. Provinces with productivity growth rates around 5% per year are Hebei, Hainan, Guangdong, Shandong, Jilin, Heinan, and Zheijang. A second set of provinces cluster around growth annual rates of 3%. The worst performer was Tibet, which actually experienced a productivity decline.

In Figure 1 we aggregate performance in three geographical regions: East, Center, and West (see Table 4 for a list of the provinces assigned to each region).. The East (with an average annual TFP growth rate of 5.7%) outperformed the Central (TFP growth of 2.9%/year) and West (TFP growth of only 0.9%/year) during this period. It is interesting to note that the TFP growth rates in the West region improved rapidly after 2000, while those of the East region slightly decreased. By 2004-2005, TFP growth rates in all three regions had converged to about 3%/year.[4]

Some of the factors that might have affected economic performance during this period are: 1) bad weather conditions in the late 1990's; 2) government efforts to encourage diffusion and

---

[3] Annual total factor productivity growth indexes for province and regions from the Malmquist method are given in Appendix Table A1.

[4] A reviewer suggested that the Central region be divided into a North Central and a South Central region given differences in agronomic characteristics. We found that doing this shows that in later years, the North Central region has marginally outperformed the South Central region. On average annual TFP growth rates are 3.3% for the North Central and 2.5% for the South Central region.

adoption of new technologies and production processes; 3) elimination of the rationing system in years 1994 and 1995; 4) steady decline in procurement prices during this period; 5) introduction of the Grain-Bag Responsibility System in 1995; 6) a new round of reforms around 1998 (especially, a second HRS with renegotiation of land contracts), 7) the reinforcement of market oriented policies and tax exemptions to the agricultural sector, and 8) WTO membership.

Stochastic Production Frontier

As an alternative to the Malmquist index a stochastic parametric translog production frontier is econometrically estimated, following Battese and Coelli (1992), to use in the calculation of TFP growth rates. The specification used is:

$$\ln Y_{it} = \alpha_0 + \sum_m \alpha_m \ln x_{mit} + \alpha_t t + \frac{1}{2}\sum_m \sum_n \beta_{mn} \ln x_{mit} \ln x_{nit} + \frac{1}{2}\beta_{tt} t^2 + \sum_m \beta_{tm} \ln x_{mit} * t + v_{it} - u_{it}$$

$$i=1,\ldots,30;\ t=1,\ldots,9, \qquad (3)$$

where Y_{it} is output level of the *i-th* province in the *t-th* time period, x_{it} are inputs (land, labor, fertilizer and machinery), t a time trend representing disembodied technical change, β are coefficients to be estimated, v are random errors assumed to be iid N $(0, \sigma_V{}^2)$, u are assumed to be one sided errors distributed iid HN ($\mu, \sigma_V{}^2$) and independent of *v*. $u_{it} = (u_i \exp(-\eta(t-T)))$ and accounts for technical inefficiency, η is a parameter to be estimated.

Equation (3) is estimated using Coelli's Frontier 4.1 econometric package with symmetry imposed. The maximum likelihood estimates of the parameters are in Table 5. Yearly production elasticities evaluated at the mean of the variables, in Table 6, indicate that the estimates are not globally concave. Nevertheless, they show a decreasing production elasticity of land and labor and an increasing production elasticity for fertilizer and machinery over time.

Technical change is obtained through differentiation of equation (3) with respect to *t:*

$$\frac{\partial \ln Y_{it}}{\partial t} = \alpha_t + \beta_{tt} t + \sum_m \beta_{tm} \ln x_{mit} \tag{4}$$

Technical efficiency level of region *i* at time *t* is defined as follows:

$$TE_{it} = \exp(-u_{it}) \tag{5}$$

and efficiency change is the difference in TE across years.

The growth rate of TFP change is defined as the rate of change in output that is not accounted for by input change (where a dot over a variable represents rate of change):

$$T\dot{F}P = \dot{y} - \sum_m \varepsilon_m \dot{x}_m = \textit{Technical change} + \textit{Efficiency change} \tag{6}$$

where ε_m are input production elasticities, m =land, labor, machinery and fertilizer..

The national, regional and provincial average rates of technical and efficiency change and the rates of TFP change for years 1993 to 2005 are reported in tables 7 and 8. We estimate strong and positive rates of technical change and a negative rate of efficiency change throughout the period. This yields positive TFP growth rates throughout the period of analysis. The average annual TFP change for the whole period is estimated to be about 4%, showing a slight declining trend, as evident in Figure 2.. The translog functional form used here smoothes out yearly changes and imposes linearity in technical change. This turns out to be a very restrictive maintained hypothesis when inflexions are present and might explain the different patterns of evolution of the TFP growth rates across methods.

In Table 8 we present the econometric estimates of TFP growth by province. Liaoning, Zhejiang, Shanghai and Fujian define the frontier throughout the period. The average TFP growth rates across provinces are less dispersed than in the Malmquist estimation. The TFP growth rates for Shanghai, Hainan, Beijing, Liaoning and Fujian are the highest, about 5% to 6%

per year. Tibet, Ningxia, Guizhou, and Qinghai show the lowest rate of growth.[5]. A summary of the information in these tables is presented in Figure 4 where the evolution of the annual growth rate of TFP is shown for three regions, with the East (4.6%) performing better than the Central (3.7%) and West (3.5%) region.[6] Again, the pattern of these evolutions mimic the evolution of the TFP growth rates for the whole country and do not show the variability evident in the evolution of TFP growth rates estimated non-parametrically with the Malmquist index. While the Malmquist index is subject to extreme variability because it relies on information of two consecutive periods only and because of it deterministic nature, the econometric estimates may suffer from specification error from the linearity evident in equation 4.

Only a few previous studies estimated provincial agricultural productivity growth rates for a period as recent as the one in our paper (see Table 1). For the overlapping years, our results are consistent with those of Lambert and Parker (1998), Colby, Diao and Somwaru (2000), Wu et al. (2001), Fan and Zhang (2002), Lezin and Wei (2005), Hsu, Yu and Chang . (2003), Dekle and Vandenbroucke (2006) and Bosworth and Collins (2008). The differences between results in this study and those of Jin et al. (2002) and Meade (2003) are not surprising considering the many differences in terms of data, periods and sectors covered. Jin et al. (2002) used data collected by the State Price Bureau and calculated provincial and national TFP indices based on a sampling framework. Meade (2003), on the other hand, uses a time series of provincial data and obtains TFP growth rates residually from the estimation of a Cobb-Douglas production function.

Only the studies by Dekle and Vandenbroucke (2006) and Bosworth and Collins (2008) include information up until 2004. Bosworth and Collins (2008)uses the same approach as Meade (2003) with data for the country as a whole obtained from China's Statistical Yearbook.

---

[5] Detailed information for all provinces and all years from the stochastic frontier method is provided in the Appendix Table A2.
[6] Separating the Central region into a North Central and a South Central shows that the North Central region outperformed the South Central region throughout the whole period. Average TFP growth rate in the North Central is 4.2% versus 3.7% in the South Central.

Dekle and Vandenbroucke (2006) also fit a Cobb-Douglas production function but using provincial data. Consistent with our results, both studies found evidence of positive TFP growth rates.

There are many multi-country studies that include China among the many countries included in the analysis. These studies use FAO as the source of data, focus on a national aggregate and cover a period of time starting in 1961. These studies are not methodologically comparable to ours but they are of empirical interest. We mention here two of the latest studies of this type, Nin Pratt, Yu and Fan (2010) and Fuglie (2008). Nin Pratt, Yu and Fan (2010) calculate Tornquist and Malmquist indexes for fifty nine countries, one of them China. Both indexes yield high and positive average rates of growth of agricultural TFP in China, but also both identify some slowdown in the 1990's. Fuglie's (2008) study calculates productivity growth for a large set of countries using a fixed weight index for the 1961-2006 period. These weights are carefully calculated with expenditure data from a reduced set of countries then applied to other countries in the same geographical area. China's weights are calculated with information from China's Statistical Bureau. For the period of interest Fuglie (2008) estimated a rate of TFP growth in Chinese agriculture of approximately 3.5%/year. The rates obtained for China in these two multi-country studies are consistent with the ones in this study.

Conclusions

In this study a Malmquist index and a stochastic production frontier are estimated to examine agricultural productivity growth in China's provinces during 1993 to 2005. Three important conclusions follow.

First, China achieved high rates of agricultural productivity growth throughout the whole period. The average annual TFP growth rate estimated is around 4% per year. These rates are supported by high rates of technical change indicating that agricultural productivity growth in China was driven by technological innovations rather than increases in input use. Productivity growth rates show a slowdown during the 1990s, a rebound in the early 2000's and a slight slowdown in 2004 and 2005.

The second major finding from this study is that there have been significant regional disparities in productivity performance. Among the three regions, the East outperforming the Central and West. The evolution of productivity growth among these regions though shows a different pattern across methods. The Malmquist index shows an important improvement in performance in the West, not much change in the Central region, and a slight deterioration through time in the East, indicating a convergence between them over time. Stochastic frontier estimates show all three regions with slight deteriorations through time.

Finally, this study shows important differences across methods in the estimation of productivity growth rates. While the Malmquist index reveals that average annual TFP growth rates in China decreased from 6% in 1994 to 0.3% in 1998 followed then by an increase to 2% to 4% after 1998, the econometric stochastic frontier estimates indicate a slight but continuous decline in TFP growth from 4.5% to 3.5% during the period of analysis. These differences are also notable in the evolution of the regional TFP growth rates as we pointed out above. We suspect that the choice of an econometric specification such as the translog implies a strong maintained hypothesis on the derivatives of the level function of interest. The Malmquist results show wide variation across years leading to question its deterministic nature and the fact that it uses information only on two adjacent periods possibly making it very sensitive to data errors and to any temporary changes in the data. Caution indicates that studies of productivity growth should use alternative approaches. While the Malmquist index, due to its nature, exacerbates variability, the econometric estimates exacerbate uniformity and smoothness.

The findings of this study are important because they provide a contrast with most other studies of Chinese agricultural productivity growth. By estimating rates of productivity growth for thirty provinces using two different approaches and an alternative data source we provide additional information that support results of earlier studies and extend the period of analysis. Future research should look into understanding the differences in patterns most obvious in our Malmquist estimates.

References

Alauddin, M., Headey, D. and Prasada Rao, D. (2004) Explaining agricultural productivity levels and growth: an international perspective. *CEPA Working Papers Series,* WP02, 2005, School of Economics, University of Queensland, Australia.

Battese, G. E. and Coelli, T. (1992) Frontier production functions, technical efficiency and panel data: with application to Pady farmers in India. *Journal of Productivity Analysis*, 3, 153-169.

Battese, G. E. and Coelli, T. (1992) A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, 20, 325-332.

Bosworth, B. and Collins, S. (2008) Accounting for growth: comparing China and India. *Journal of Economic Perspectives*, 22, 1, 45–66.

Bravo Ortega, C. and Lederman, D. (2004) Agricultural productivity and its determinants: revisiting international experiences**.** *Estudios de Economia*, 31, 2, 133-163.

Coelli, T. (2007) A guide to Frontier Version 4.1: a computer program for stochastic frontier production and cost function estimation. Centre for Efficiency and Productivity Analysis, University of Queensland, Australia. Available at: "http://www.une.edu.au/econometrics/cepa.htm".

Coelli, T. (2008) A guide to DEAP Version 2.1: a data envelopment analysis (computer) program. Centre for Efficiency and Productivity Analysis, University of Queensland, Australia. Available at: "http://www.une.edu.au/econometrics/cepa.htm".

Coelli, T. and Prasada Rao, D. S. (2005) Total factor productivity growth in agriculture: a Malmquist Index analysis of 93 countries, 1980–2000. *Agricultural Economics*, 32, 1, 115-134.

Colby, Hunter, Diao, X. and Somwaru, A. (2000) Cross-commodity analysis of China's grain sector: sources of growth and supply response. Technical Bulletin 1884, Economic Research Service, U.S. Department of Agriculture, Washington, DC.

DeBrauw, A. Huang, J. and Rozelle, S. (2000) Responsiveness, flexibility, and market liberalization in China's agriculture. *American Journal of Agricultural Economics*, 82, 5, 1133-1139.

Dekle, R. and Vandenbroucke, G. (2006) Wither Chinese growth? a sectoral accounting approach. Working Paper, Department of Economics, University of Southern California, June.

Fan, S. (1991) Effects of technological change and institutional reform on production growth in Chinese agriculture. *American Journal of Agricultural Economics*, 73, 2, 266-275.

Fan, S. (1997) Production and productivity growth in Chinese agriculture: new measurement and evidence. *Food Policy,* 22, 3, 213-228.

Fan, S. and Zhang, X. (2002) Production and productivity growth in Chinese agriculture: new national and regional measures, *Economic Development and Cultural Change*, 50, 819-38.

Färe. R., Grosskopf, S. and Lovell, C. A. K. (1994) *Production Frontiers*. Cambridge University Press, Cambridge.

Fuglie, K. (2008) Is a slowdown in agricultural productivity growth contributing to the rise in commodity prices? *Agricultural Economics*, 39, supplement 431–441.

Fulginiti, L. and Perrin R. (1993) Prices and productivity in agriculture. *Review of Economics and Statistics*, 75, 471-482.

Hsu, S., Yu, M.and Chang, C. (2003) An analysis of total factor productivity growth in China's agricultural sector. *AgEconSearch*, Department of Applied Economics, University of Minnesota.

Huang, J. and Rozelle, S. (1995) Environmental stress and grain yields in China. *American Journal of Agricultural Economics*, 77, 853-864.

Jin, S., Huang, J., Hu, R. and Rozelle, S. (2002) The creation and spread of technology and total factor productivity in China's agriculture. *American Journal of Agricultural Economics*, 84, 4, 916-930.

Jin, S., Hengyun Ma, H., Huang, J., Hu, R. and Rozelle, S. (2010) Productivity, efficiency and technical change: measuring the performance of China's transforming agriculture. *Journal of Productivity Analysis,* 33:191–207.

Lambert, D. and Parker, E. (1998) Productivity in Chinese provincial agriculture. *Journal of Agricultural Economics,* 49, 3, 378-392.

Lezin, A-B. and Wei, L. (2005) Agricultural productivity growth and technology progress in developing country agriculture: case study in China. *Journal of Zhejiang University Science*, 6A, Suppl. I, 172-176.

Lin, J. Y. (1992) Rural reforms and agricultural growth in China. *American Economic Review*, 82, 34-51.

Lin, J.Y. (1993) Cooperative farming and efficiency: theory and empirical evidence from China, in C. Csaba and Y. Kislev (eds.), *Agricultural Cooperatives in Transition*. Westview Press, Boulder, Colorado.

Lin, J. Y. (1995) Endowments, technology, and factor markets: a natural experiment of induced institutional innovation from China's rural reform. *American Journal of Agricultural Economics,* 77, 231-242.

Lin, J. Y. (1997) Institutional reforms and dynamics of agricultural growth in China. *Food Policy*, 22, 3, 201-212.

Ludena C., Hertel, T., Preckel, P., Foster, K. and Nin, A. (2007) Productivity growth and convergence in crop, ruminant, and non-ruminant production: measurement and forecasts. *Agricultural Economics*, 37, 1, 1 – 17.

McMillan, J., Whalley, J. and Zhu, L. (1989) The impact of China's economic reforms on agricultural productivity. *The Journal of Political Economy*, 97, 4, 781-807.

Mead, R. (2003) A revisionist view of Chinese agricultural productivity? *Contemporary Economic Policy*, 21, 1, 117-131.

Nin Pratt, A., Yu, B. and Fan, S. (2009) The total factor productivity in China and India: new measures and approaches. *China Agricultural Economic Review*, 1, 1, 9-22.

Rozelle, S., Taylor, J. and DeBrauw, A. (1999) Migration, remittances, and agricultural productivity in China. *American Economic Review*, 89, 287-291.

Rozelle, S., Part, A., Huang, J. and Jin, H. (1997) Liberalization and rural market integration in China. *American Journal of Agricultural Economics*, 79, 635-642.

Spitzer, M. (1997) Interregional comparison of agricultural productivity growth, technical progress, and efficiency change in China's agriculture: a nonparametric index approach. *INTERIM REPORT IR-97-89 /December.*

State Statistical Bureau (1994-2000) *China Statistical Yearbook*. China Statistical Press, Beijing (various issues) Available for 1995 onward at (www.stats.gov.cn/english/statisticaldata/yearlydata/.

Wu, S., Walker, D., Devadoss, S. and Lu, Y. (2001) Productivity growth and its components in Chinese agriculture after reforms. *Review of Development Economics*, 5, 3, 375–391.

Young, A. (2003) Gold into base metals: productivity growth in the people's republic of China during the reform period. *Journal of Political Economy,* 111, 6, 1220-1261.

Zhang, B. and Carter, C. (1997) Reforms, the weather and the productivity growth in China's grain sector. *American Journal of Agricultural Economics*, 79, 1266-1277.

Zhang, X. and Fan, S. (2001) Estimating crop-specific production technologies in Chinese agriculture: a generalized maximum entropy approach. *American Journal of Agricultural Economics*, 83, 378-388.

Table 1. Studies of TFP growth in Chinese Agriculture.
(figures indicate the estimated annual growth rate (%) in agricultural TFP)

Studies using provincial data

Author	Method*	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Avg.
This study (Tong et al, 2012)	SPF	4.5	4.5	4.4	4.3	4.2	4.1	4.0	3.9	3.8	3.7	3.6	3.6	4.0
	DEA-M	6.3	2.7	4.1	1.3	0.9	4.6	3.0	4.1	4.3	3.9	2.3	2.4	3.3
Lambert et al (1998)	A-D						1993-1995							5.8
Jin et al (2002)	A-D	-6.3	0.0											-3.2
Mead (2003)	CD	2.1	-0.5	-1.0										0.2
Deckle et al (2006)	CD	9.1	4.2	16.0	6.9	3.2	12.5	8.9	2.0	2.0	1.0			6.6

Studies using national data

Author	Method	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Avg.
Colby et al (2000)	A-D						1995-1997							0.8
Wu et al (2001)	DEA-M	3.9	0.6											2.3
Fan et al (2002)	A-D	6.0	6.5	4.7	0.2									4.3
Hsu et al (2003)	DEA-M						1993-2000							1.0
Lezin et al (2005)	Review	1.7	1.9	-0.2	1.6									1.3
Bosworth et al (2008)	CD						1993-2004							1.7

Cross-Country Studies

Author	Method	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Avg.
Fuglie (2008)	CD			1990-1999			3.8			2000-2006			3.2	3.5
Nin Pratt et al (2009)	DEA-M	5.9	2.8	8.1	2.5	4.9	-2.3	7.1	4.9	5.9	4.4			4.9
	A-D	3.6	3.4	3.7	6.0	-1.9								3.0

*Methods:
SPF = Stochastic Production Frontier
DEA-M = Malmquist index based on Data Envelopment Analysis
A-D = Growth accounting method with Divisia or Tornqvist-Thiel Index
CD = Cobb-Douglas production function estimation or growth accounting

Table 2. Major Agricultural Output and Input Measures for Chinese Agriculture, 1993-2005

	Gross Output Value (Constant 1993 Yuan, 100 millions)	Land Sown (10,000 hectares)	Fertilizer (10,000 metric tons)	Labor (10,000 persons)	Machinery Power (10,000 kw)
1993	10,996	14,774	3,152	33,258	31,817
1994	11,931	14,824	3,318	32,690	33,802
1995	13,232	14,988	3,594	32,335	36,118
1996	14,473	15,238	3,828	32,261	38,547
1997	15,215	15,397	3,981	32,435	42,079
1998	16,119	15,571	4,086	32,627	45,208
1999	16,880	15,637	4,124	32,912	48,996
2000	17,485	15,630	4,147	32,798	52,574
2001	18,234	15,571	4,254	32,451	55,172
2002	19,136	15,464	4,339	31,991	57,930
2003	19,855	15,241	4,412	31,260	60,387
2004	21,327	15,355	4,637	30,596	64,028
2005	22,521	15,549	4,766	29,976	68,398
Annual rate of change (%)	5.97	0.43	3.46	-0.87	6.37

Source: *China Statistical Yearbook*, State Statistical Bureau (various annual issues).

Table 3. Productivity Growth Indexes for China's Agriculture, 1993-2005: Malmquist Method

Year	Total Factor Productivity	Technical Efficiency	Technical Change	Total Factor Productivity [1]	Efficiency Change	Technical Change
	(index, 1993 = 100)			(annual growth rate in %)		
1993	100	100	100	--	--	--
1994	106	96	111	5.9	-4.1	10.4
1995	109	94	116	2.3	-2.3	4.7
1996	113	96	118	3.8	2.4	1.4
1997	114	86	135	1.2	-10.7	13.3
1998	114	87	134	0.3	1.0	-0.7
1999	119	85	143	3.8	-2.6	6.6
2000	122	85	146	2.8	0.4	2.4
2001	127	80	163	4.0	-6.3	11.0
2002	133	80	171	4.2	-0.4	4.7
2003	138	77	185	3.8	-3.5	7.6
2004	141	80	182	2.1	3.6	-1.5
2005	144	81	183	2.3	1.8	0.5
Average annual growth rate (unweighted)				3.03	-1.80	4.93
Average annual growth rate (weighted by output)				3.98		

[1] The rate of growth in total factor productivity equals the rate of efficiency change plus the rate of technical change.

Table 4. Agricultural Productivity Growth in China's Provinces and Regions: Malmquist Method

Regions	Provinces	Total Factor Productivity Growth	Efficiency Change	Technical Change
		(average annual growth rate in %, 1994-2005)		
East*		5.7	-0.8	6.8
	Beijing	5.9	0.0	5.9
	Fujian	6.9	-1.9	9.0
	Guangdong	5.5	-1.7	7.3
	Guangxi	2.1	-1.7	3.9
	Hainan	5.6	0.0	5.6
	Hebei	5.6	-0.3	5.9
	Jiangsu	7.4	-0.5	7.9
	Liaoning	6.1	0.4	5.7
	Shandong	5.4	-1.8	7.3
	Shanghai	5.8	0.0	5.8
	Tianjing	2.5	-3.2	5.9
	Zhejiang	4.9	-0.1	5.0
Central*		2.9	-1.9	5.4
	Anhui	2.1	-3.0	5.3
	Heilongjiang	2.8	-1.4	4.3
	Henan	5.0	-1.8	6.9
	Hubei	2.3	-3.6	6.2
	Hunan	2.1	-0.9	3.0
	Inner Mongolia	0.1	-3.4	3.6
	Jiangxi	0.5	-3.7	4.4
	Jilin	5.0	-1.5	6.6
	Shanxi	1.5	-2.2	3.8
West*		0.9	-2.8	4.3
	Gansu	1.6	-0.7	2.3
	Guizhou	-2.1	-5.9	4.0
	Ningxia	1.1	-2.7	3.9
	Qinghai	2.1	0.3	1.7
	Shaanxi	2.0	-3.1	5.3
	Sichuan	0.4	-3.9	4.6
	Tibet	-1.2	-1.3	0.1
	Xinjiang	2.7	-2.1	4.9
	Yunnan	0.2	-1.9	2.1

*Output weighted regional averages

Table 5. Translog Stochastic Frontier Maximum Likelihood Estimates for China's Agriculture

Parameters (description)	Parameters (symbols)	Coefficient Estimates	Standard Error	T-ratio
Intercept	α_0	4.7258	1.3598	3.48
log(land)	α_D	-2.2786	0.5841	-3.90
log(labor)	α_L	1.7028	0.3488	4.88
log(fertilizer)	α_F	0.0667	0.3793	0.18
log(power)	α_P	0.7554	0.2997	2.52
time	α_t	0.1002	0.0214	4.69
log(land)^2	β_{DD}	0.2907	0.0976	2.98
log(labor)^2	β_{LL}	0.0214	0.0369	0.58
log(fertilizer)^2	β_{FF}	0.0644	0.0333	1.93
log(power)^2	β_{PP}	0.0030	0.0257	0.12
log(land)*log(labor)	β_{DL}	-0.1863	0.0998	-1.87
log(land)*log(fertilizer)	β_{DF}	-0.2896	0.1041	-2.78
log(land)*log(power)	β_{DP}	0.0171	0.0958	0.18
log(labor)*log(fertilizer)	β_{LF}	0.2304	0.0616	3.74
log(labor)*log(power)	β_{LP}	-0.1841	0.0565	-3.26
log(fertilizer)*log(power)	β_{FP}	0.0903	0.0493	1.83
log(land)*time	β_{Dt}	-0.0057	0.0069	-0.83
log(labor)*time	β_{Lt}	-0.0034	0.0038	-0.88
log(fertilizer)*time	β_{Ft}	0.0038	0.0041	0.92
log(power)*time	β_{Pt}	0.0015	0.0038	0.40
time^2	β_{tt}	-0.0009	0.0003	-3.45

The econometric model is estimated using annual panel data for 30 provinces over 1993-2005.

Table 6. Estimated Production Elasticities for China's Agriculture

	Land	Fertilizer	Labor	Power
1993	0.124	0.453	0.206	0.075
1994	0.110	0.464	0.202	0.084
1995	0.091	0.478	0.203	0.096
1996	0.078	0.490	0.199	0.104
1997	0.068	0.505	0.186	0.109
1998	0.061	0.517	0.174	0.112
1999	0.055	0.530	0.158	0.114
2000	0.049	0.540	0.142	0.117
2001	0.037	0.550	0.136	0.123
2002	0.025	0.560	0.129	0.129
2003	0.011	0.568	0.124	0.136
2004	0.000	0.577	0.119	0.146
2005	-0.001	0.581	0.106	0.155
Mean	0.054	0.524	0.160	0.115

These elasticities are derived from the estimated translog stochastic frontier production function (see Table 5) evaluated at the mean values of the variables for 30 provinces.

Table 7. Productivity Growth Indexes for China's Agriculture, 1993-2005: Stochastic Frontier Method

Year	Total Factor Productivity	Technical Efficiency	Technical Change	Total Factor Productivity [1]	Efficiency Change	Technical Change
	(index, 1993 = 100)			(annual growth rate in %)		
1993	100	100	100	--	--	--
1994	105	99	106	4.5	-1.1	5.6
1995	109	98	112	4.4	-1.1	5.5
1996	114	97	118	4.4	-1.1	5.5
1997	119	96	125	4.3	-1.1	5.4
1998	124	95	131	4.2	-1.2	5.3
1999	130	93	138	4.1	-1.2	5.2
2000	135	92	146	4.0	-1.2	5.2
2001	140	91	153	3.9	-1.2	5.1
2002	146	90	161	3.8	-1.2	5.0
2003	151	89	170	3.7	-1.3	5.0
2004	157	88	178	3.6	-1.3	4.9
2005	162	87	187	3.5	-1.3	4.8
Average annual growth rate (unweighted)				4.04	-1.19	5.23
Average annual growth rate (weighted by output)				4.13	-0.89	5.02

[1] The rate of growth in total factor productivity equals the rate of efficiency change plus the rate of technical change.

Table 8. Agricultural Productivity Growth in China's Provinces and Regions: Stochastic Frontier Method

Regions	Provinces	Total Factor Productivity Growth	Efficiency Change	Technical Change
		(annual growth rate in %)		
East*		4.6	-0.6	5.2
	Beijing	5.4	-1.0	6.4
	Fujian	5.1	-0.3	5.4
	Guangdong	5.0	0.0	5.1
	Guangxi	3.9	-1.0	4.9
	Hainan	5.6	-0.2	5.7
	Hebei	3.8	-1.3	5.1
	Jiangsu	4.5	-0.6	5.1
	Liaoning	5.2	-0.2	5.3
	Shandong	4.2	-0.8	5.0
	Shanghai	5.9	-0.3	6.2
	Tianjing	4.8	-1.5	6.3
	Zhejiang	4.9	-0.2	5.2
Central*		3.7	-1.2	5.0
	Anhui	3.6	-1.3	4.9
	Heilongjiang	3.6	-1.2	4.9
	Henan	3.4	-1.4	4.8
	Hubei	4.0	-1.1	5.1
	Hunan	3.9	-0.8	4.8
	Inner Mongolia	3.6	-1.4	5.1
	Jiangxi	4.0	-0.9	4.9
	Jilin	4.2	-1.1	5.3
	Shanxi	3.1	-2.2	5.3
West*		3.5	-1.3	4.8
	Gansu	3.2	-1.8	5.0
	Guizhou	2.9	-1.8	4.6
	Ningxia	3.0	-2.8	5.8
	Qinghai	2.8	-2.8	5.7
	Shaanxi	3.4	-1.7	5.1
	Sichuan	3.5	-0.9	4.4
	Tibet	3.0	-2.8	5.8
	Xinjiang	4.5	-1.0	5.4
	Yunnan	3.3	-1.4	-4.7

*Output weighted regional averages

Figure 1 – Agricultural TFP Growth Rates by Region over 1994-2005: Malmquist Method

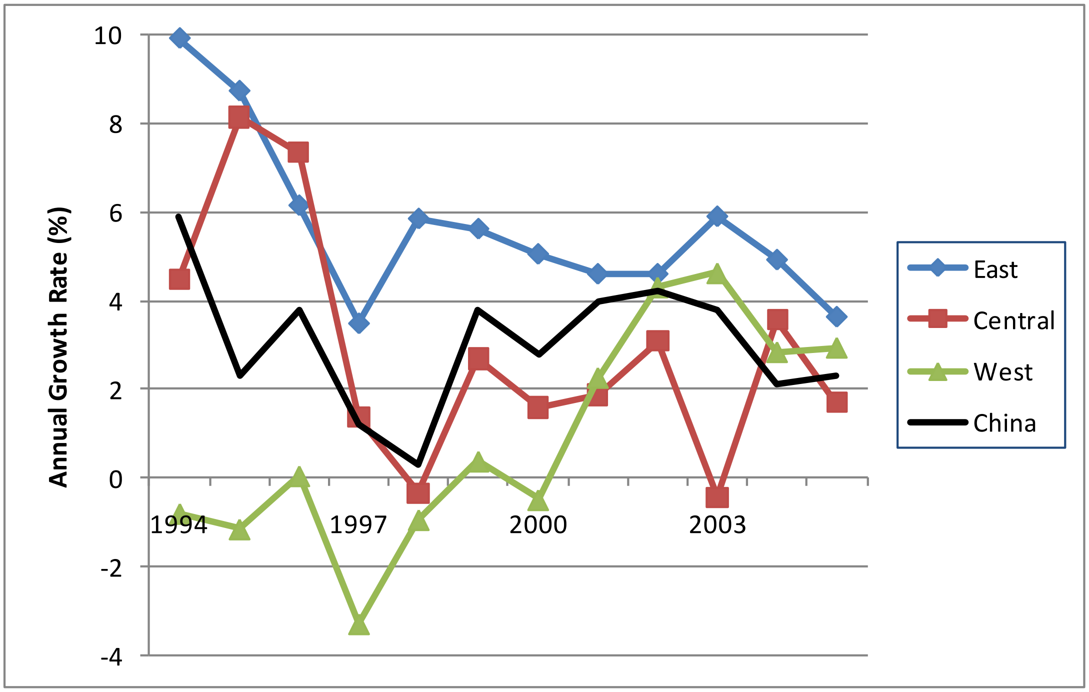
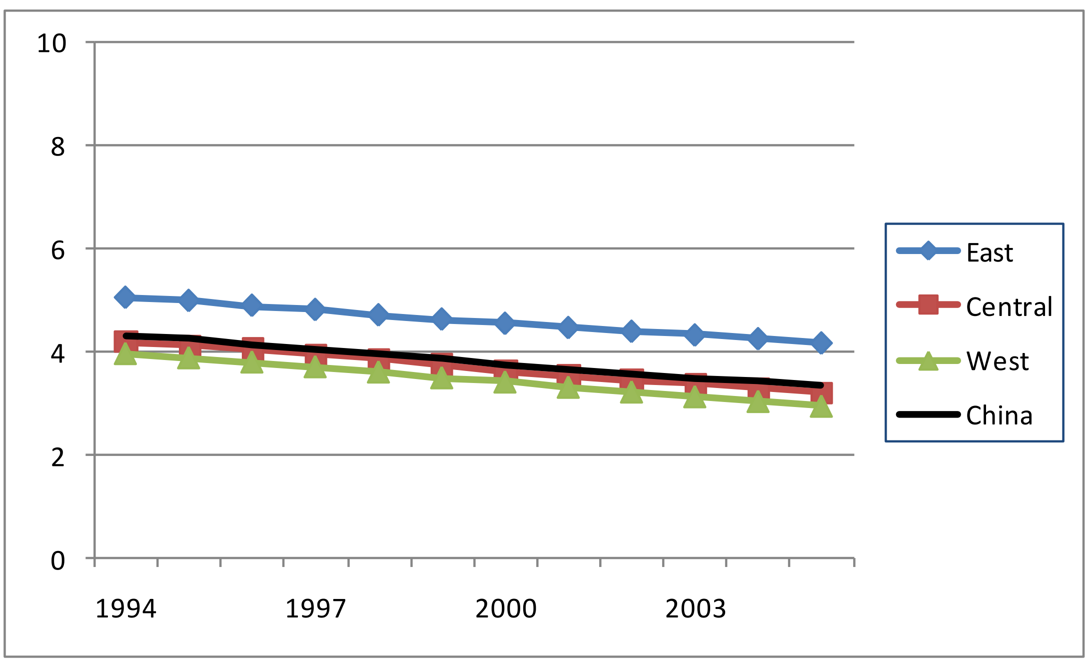


Figure 2 – Agricultural TFP Growth Rates by Region over 1994-2005: Stochastic Frontier Method



Appendix: Regional and Provincial TFP Growth Rates for China's Agriculture

Table A9.1 - Agricultural TFP Indexes for China's Provinces and Regions: Malmquist Method

		TFP Index (1993=100)											
Region	Province	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
East		105	111	116	122	128	134	140	146	153	160	167	174
	Beijing	102	104	103	104	104	105	125	151	186	211	210	209
	Fujian	111	125	136	146	152	162	175	187	197	213	223	230
	Guangdong	103	108	116	119	124	137	145	150	170	178	188	194
	Guangxi	101	112	113	123	121	124	123	121	124	125	125	130
	Hainan	112	121	119	125	132	163	156	175	179	183	191	200
	Hebei	112	125	129	139	146	154	163	171	177	186	194	197
	Jiangsu	113	127	135	132	136	144	153	163	170	187	221	243
	Liaoning	102	113	131	134	157	162	163	174	187	197	203	212
	Shandong	122	134	142	146	159	166	173	177	179	189	192	194
	Shanghai	112	118	132	157	152	142	157	173	186	214	214	207
	Tianjing	100	99	99	104	117	114	117	126	128	137	130	137
	Zhejiang	111	116	123	127	140	145	162	168	166	176	179	181
Center		104	109	113	118	122	127	132	137	141	146	151	156
	Anhui	98	109	116	123	120	130	128	125	135	122	134	132
	Heilongjiang	109	119	129	121	107	112	112	119	123	131	137	143
	Henan	102	124	139	147	154	164	166	173	173	169	181	185
	Hubei	107	119	123	129	125	127	132	134	132	132	132	133
	Hunan	103	107	110	114	112	115	120	123	126	128	127	129
	Inner Mongolia	105	96	109	100	107	104	108	106	106	101	104	103
	Jiangxi	108	110	115	113	106	103	105	105	106	110	106	107
	Jilin	112	113	128	119	134	130	125	133	152	161	171	187
	Shanxi	103	104	115	108	117	106	115	110	123	127	130	122
West		104	108	112	117	121	125	130	134	138	143	147	152
	Gansu	99	95	97	92	104	100	105	112	113	117	122	123
	Guizhou	102	99	93	89	82	76	73	75	73	75	78	78
	Ningxia	95	94	108	107	90	91	103	109	117	122	120	119
	Qinghai	102	92	94	100	106	106	103	109	112	115	121	130
	Shaanxi	99	97	108	99	102	97	103	107	114	113	124	130
	Sichuan	97	99	99	95	90	85	85	87	94	101	103	107
	Tibet	169	126	99	103	71	147	146	156	160	170	138	142
	Xinjiang	104	102	96	99	107	113	116	119	123	128	132	139
	Yunnan	96	94	92	91	94	116	102	99	99	102	103	105
National average		107	109	114	115	117	122	126	131	137	142	145	149

Table A9.2 - Agricultural TFP Indexes for China's Provinces and Regions: Stochastic Frontier Method

		TFP Index (1993=100)											
Region	Province	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
East		110	121	128	133	141	149	157	164	172	182	191	198
	Beijing	106	112	119	126	133	140	148	156	164	173	182	189
	Fujian	106	112	118	124	130	137	144	152	159	167	175	181
	Guangdong	106	112	118	124	131	137	144	152	159	167	175	183
	Guangxi	104	109	114	119	123	128	133	139	144	149	154	160
	Hainan	106	113	119	126	134	141	149	157	166	175	185	195
	Hebei	104	109	113	118	123	128	132	137	142	147	152	157
	Jiangsu	105	110	116	122	127	133	140	146	152	159	166	172
	Liaoning	106	112	118	125	132	139	146	153	161	169	177	186
	Shandong	105	110	114	120	125	130	136	141	147	153	159	164
	Shanghai	107	114	121	129	136	145	153	162	172	182	192	199
	Tianjing	105	111	117	123	129	135	142	148	155	163	170	178
	Zhejiang	105	111	117	123	130	136	143	150	157	165	173	178
Center		105	113	122	124	123	127	129	131	135	135	140	142
	Anhui	104	108	113	117	122	126	130	135	140	144	149	154
	Heilongjiang	104	109	113	118	123	127	132	136	141	145	150	154
	Henan	104	108	112	116	120	125	129	133	137	141	145	151
	Hubei	104	109	114	119	124	129	134	139	145	150	156	160
	Hunan	104	109	114	119	123	128	133	139	144	149	154	163
	Inner Mongolia	104	108	113	117	122	126	131	135	140	145	149	156
	Jiangxi	104	109	114	119	124	129	134	139	144	150	155	163
	Jilin	105	110	115	120	125	131	136	142	148	153	159	165
	Shanxi	104	107	111	115	119	123	126	130	134	137	141	148
West		99	98	98	95	94	94	94	96	100	105	108	111
	Gansu	104	108	111	115	119	123	127	131	135	138	142	146
	Guizhou	104	107	111	114	118	121	124	128	131	135	138	141
	Ningxia	104	107	111	115	119	122	126	129	133	136	140	143
	Qinghai	104	107	111	114	118	121	124	128	131	135	138	141
	Shaanxi	104	108	112	116	120	124	129	133	137	142	146	150
	Sichuan	104	108	112	117	121	125	130	134	139	143	148	153
	Tibet	104	107	111	114	118	122	126	129	133	136	140	143
	Xinjiang	105	110	116	122	128	133	139	145	152	158	165	171
	Yunnan	104	108	112	116	120	124	129	133	137	141	145	149
National average		105	109	114	119	124	130	135	140	146	151	157	163